

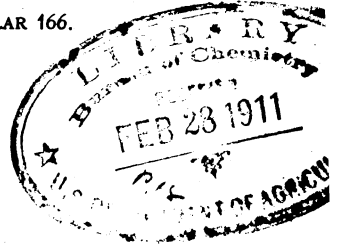
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A. D. MELVIN, CHIEF OF BUREAU.



THE DIGESTIBILITY OF CHEESE.

BY

C. F. DOANE,

Assistant Dairyman, Dairy Division,

IN COOPERATION WITH

THE OFFICE OF EXPERIMENT STATIONS.



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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., November 26, 1910.

SIR: I have the honor to transmit herewith and to recommend for publication as a circular of this Bureau the accompanying manuscript entitled "The Digestibility of Cheese," by C. F. Doane, Assistant Dairyman in the Dairy Division of this Bureau. The work described in the paper comprised a thorough study of the food value of several varieties of cheese, particularly the American or Cheddar, under a great diversity of conditions. The experiments were carried out with human subjects with the cooperation of the Office of Experiment Stations of this Department. Two series of experiments were conducted, one at the Wesleyan University, Middletown, Conn., the other at the Minnesota State Experiment Station. Acknowledgment is made of assistance rendered by Dr. C. F. Langworthy, in charge of nutrition investigations of the Office of Experiment Stations, in preparing this work for publication.

Some important results were secured, particularly with regard to the popular theory that cheese, especially when green or unripened, is difficult to digest. The experiments proved conclusively that there is no warrant for this belief. The paper also presents some strong reasons for increasing the consumption of cheese by American people, both from the point of view of economy and for its superior food value. It is well known that at the present time the consumption of cheese in this country is far below that of European countries.

Respectfully,

A. D. MELVIN,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.



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THE DIGESTIBILITY OF CHEESE.

INTRODUCTION.

This report covers an exhaustive study of the food value and digestibility of American or Cheddar cheese in various stages of ripening. In addition, a few experiments were made with some purely foreign varieties of cheese.

The work, as first planned, was intended to be purely artificial digestion experiments. After these experiments were started it was found to be very advantageous to cooperate with the Office of Experiment Stations of this Department in a series of more thorough and valuable digestion experiments with human subjects. The artificial digestion experiments were continued, but as the results simply corroborated the results of the experiments with the human subjects the detailed consideration will be confined to the latter.

The experiments with the human subjects broadened the scope of the work, as they made it possible not only to determine the comparative digestibility of cheese at different stages of ripening, but also gave the opportunity to make a study of the food value of cheese and its effects on the health of the subject when eaten in comparatively large quantities.

The extent of the experiments and the uniformity of results have helped to settle questions which had been open to doubt, and about which some evidently erroneous opinions had been formed. A number of such questions had arisen, the most prominent of which concerned the comparative digestibility of green and cured cheese. The common American cheese was formerly eaten when it had gone through what is usually termed a ripening or breaking-down process in which some very evident but not thoroughly understood chemical and physical changes take place. The process may be described as a gradual change from a rubbery or elastic consistency to a mellow and partially soluble condition. This process, under the old way of curing the cheese in the factory where warm temperatures prevailed in the summer season, was accompanied by a decided development of flavor.

Associated with the idea that the green cheese was comparatively indigestible was another belief that curd or green cheese caused constipation. In fact, there was a popular idea that cheese at any stage

of ripening had a tendency to do this, though the unripened product was supposed to have the most pronounced effect.

It is perhaps a matter of some surprise that these beliefs, especially that of comparative digestibility, had become so thoroughly established, and it is natural to seek for the reason. As was noted, there is a marked difference in the physical characteristics of the green and cured products. The water-soluble material in well-cured cheese is noticeably high, while in the uncured product it amounts to almost nothing. It is very likely that these evident physical and chemical differences have been in a large measure responsible for the popular misconceptions. But it is a well-known fact that the solids of milk are very digestible and make an almost perfect food. With the addition of rennet and the development of lactic acid in the process of cheese making some chemical changes take place, but it is rather difficult to explain why these should transform digestible solids in milk into indigestible solids in cheese. A careful study also makes it difficult to comprehend why cheese of any sort, including green cheese, should have any unusual tendency to cause constipation. This is an almost universal belief among men who make and handle cheese. It is probably due to the fact that many people are very fond of the mild-flavored curd and eat large quantities of it when it is constantly at hand. The digestive disturbances which they attribute to peculiarities in the cheese itself are probably due merely to overeating.

Another interesting phase of the question centered about the actual value of cheese as a food. The opinion has been expressed by people who are sometimes considered as authorities on dietary subjects that cheese has no place as a staple food product, being of value only as a luxury or as a so-called appetizer. This is, of course, a view of the matter to which many would not agree, as we know that it forms a large part of the diet of many persons in Europe and elsewhere. In connection with the general question of food value, therefore, the economy of different varieties of cheese in the diet as compared with other highly nitrogenous foods is well worth consideration, as under the conditions which confront a large part of the laboring class a study of the economy of different foods becomes of the greatest importance.

Among many consumers and under usual American food conditions cheese is eaten largely as a relish. As such it is supposed to have certain properties as a condiment or as an aid to the digestion of other foods. This part of the question is also well worth investigating, and in this connection many varieties of cheese come up for consideration.

As a food product in the United States the common American or Cheddar cheese (the so-called "full cream" of the dealers) stands first in the quantity made and consumed. Emmental, or the so-called

Swiss cheese, is perhaps second, while on the basis of economy the different kinds of cheese made from skimmed milk, principally cottage cheese, are of great importance. From the standpoint of condimental value two other cheeses would be supposed to be of special importance. These are Camembert and Roquefort, two highly flavored and very distinct kinds. But they are comparatively expensive and are of such a nature that few people would care to eat more than a small quantity at a time.

The first year's cooperative work in the study of the food value of cheese was done at Wesleyan University, Middletown, Conn., where the Office of Experiment Stations had extensive laboratories and a respiration calorimeter for use in nutrition investigations with man. After the completion of the first year's work it was thought advisable to conduct some experiments with an older cheese than had been used in previous experiments, and also to study some foreign varieties. The second year's work was done in cooperation with the Minnesota State Experiment Station. Dr. F. G. Benedict and Mr. R. D. Milner had charge of the work done at Middletown, and Prof. Harry Snyder of the work in Minnesota.

THE EXPERIMENTS AT MIDDLETOWN, CONN.

GENERAL PLAN OF THE WORK.

The work at Middletown was planned to include green and ripe cheese, or cheese as soon after as it was made as it was possible to ship the samples to Middletown, and cheese in all stages of ripening up to the point where it was becoming unfit for consumption. The cheese was made in a cheese factory at Plymouth, Wis., and was kept in cold storage at Plymouth. Samples were shipped by mail as the plan of the experiments demanded. The cheese was made by the regular Cheddar process, was a little better than average quality, and would represent a large part of the cheese consumed in this country. The ripening of the cheese was carried on under different conditions. One lot was ripened under factory conditions where the temperature varied from 50 to 75° F. One lot was stored immediately and kept at 32° F. One lot was stored immediately and held at 40° F. One lot was held in the factory curing room for two weeks and then placed in a temperature of 40° F. and held. All the foregoing was made with low rennet, or 3 ounces of rennet extract to 1,000 pounds of milk. This entire series was duplicated with cheese made with 6 ounces of rennet extract to 1,000 pounds of milk. The greater quantity of rennet noticeably hastens the ripening process of the cheese. The smaller quantity is customarily used.

It might be well to state that the cheese made in this country at the present time is not as firm as the Cheddar cheese made many years

ago, as it very likely contains a greater percentage of moisture and ripens or cures more rapidly. It is often said that the old English Cheddar cheese is eaten at more than a year of age. At present cheese at six months of age is fit for food only if it has been cured and held in cold storage. Cold curing certainly retards the physical changes characteristic of a well-ripened cheese and also the development of flavor. Whether it affects the chemical changes which the cheese undergoes may be considered an open question.

The diet in these experiments consisted of a basal ration of whole-wheat bread and bananas, as these two articles have been thoroughly studied and the digestion coefficients have been determined. They are to be found in many of the publications of the Office of Experiment Stations. Each experiment extended over three days. A total of 184 experiments were made and a total of 65 human subjects were used. Many of these subjects were used in only one experiment, but one subject appeared in 14 experiments. The subjects were mostly students of Wesleyan University between the ages of 19 and 32 years.

METHODS OF SAMPLING AND ANALYSIS.

FOODS.

The diet in these experiments consisted of bread, bananas, and cheese in quantities calculated sufficient to give about 2,500 calories of energy and 20 grams of nitrogen per day.

Bread.—The bread was ordinary whole-wheat bread purchased from a local bakery. On the day before the experiment a large enough number of loaves were ordered to provide for all that would be needed on that day. On the morning of the experiment itself the crust was pared from all the loaves of bread. The required amount for the day was then weighed out upon a balance, and from each loaf of bread a slice or two was set aside as a sample. This plan was carried out on each of the three days in each series of experiments.

Bananas.—The bananas were obtained from a local fruit dealer, a bunch or more at a time. On the first morning of the experiment a number of bananas estimated to be large enough for the day were peeled, and immediately the required amount for each man was weighed out and set aside. From each banana used a sample slice or two was taken from the middle or the ends of the fruit.

Cheese.—The cheese arrived at the laboratory usually on the afternoon previous to the day on which the experiment began. It was unpacked immediately and a section estimated to be large enough for the amount to be used was cut from each cheese. This section was then cut into small pieces after the outside covering had been taken off and then was put through a small meat chopper. The

cheese thus ground was thoroughly mixed, and after being treated in this manner gave a material which could be readily handled and easily weighed. The required amount for each subject was then weighed as rapidly as possible upon a balance sensitive to a tenth of a gram. As soon as each portion was weighed it was immediately packed in a half-pint jar, sealed, and put away in a refrigerator. Instead of preparing the cheese for the experiments each day, enough was prepared on the afternoon previous to the experiment to last for the three days.

Sampling.—The method of sampling the foods used in the experiment was as follows: At the beginning of the series one-fifth of the total diet for the day was placed in an evaporating dish and dried in an oven. This was repeated on the second day, one-fifth of the total diet for that day being added to the sample of the previous day. This procedure was likewise carried out for the third day. The sample thereof consisted of three portions, which included one-fifth of the total amount of cheese eaten, one-fifth of the total bread, and one-fifth of the total amount of bananas. After the experiments had been in progress for several weeks it was found that this method did not give satisfactory results. Therefore it was decided to composite the bread and bananas alone, leaving out the cheese. A separate analysis of the cheese was made, as had been done all the way through the series.

Analysis of cheese.—Determinations were made on nitrogen, fat, and heat of combustion. All analyses for fat and nitrogen were made in triplicate. The nitrogen was determined according to the Kjeldahl method, using about 0.7 gram for each sample. The determination of fat was made according to the following method: Five cubic centimeters of a mixture of equal parts by volume of anhydrous copper sulphate and pure dry sand were placed in a glass extraction tube, and above this was placed the fresh cheese, about 3 grams being used for each determination. Above the cheese was placed a layer of dry fibrous asbestos. The extraction tube was then placed inside an ordinary straight glass tube which was connected to a flat flask and still. The material thus prepared was extracted for five hours; the extraction tube was then taken off and the material ground in a glazed mortar with the addition of a little fresh sand. The material was then washed back into the extraction tube by the aid of ether and the tube was placed on the apparatus and extracted for ten hours. The rest of the procedure was the same as in ordinary fat determinations.

The heat of combustion of the food was determined by means of the Atwater-Hempel calorimetric bomb. For each determination about 0.7 gram was taken and placed in a large-sized nickel capsule. This

was dried for about a day in a Hempel desiccator at very low pressure. Triplicate determinations were made in all cases.

Food composites.—Determinations on food composites for nitrogen, fat, and heat of combustion were made, and the methods used in these determinations were those employed by the American Association of Official Agricultural Chemists.

FECES.

Separation.—The method of separating feces employed in these experiments was that usually followed in the Wesleyan University laboratory. At the beginning of the breakfast on the first day of the experiment a gelatin capsule containing powdered charcoal was given to the subject and he was instructed to take that with the first part of his meal. The subject took another capsule with the breakfast of the first day after the end of the experiment. As the experiment progressed difficulty was experienced in separating the feces by this method, and two capsules were given to the subject instead of one. As a further aid in the separation at the end of the experiment a bunch of grapes was given with the breakfast of the first day after the experiment closed. The grape seeds being indigestible were very readily discernible in the feces, and they usually came before the appearance of the lampblack in the feces following that of the food experiment.

Drying.—The fresh feces were placed in a weighed dish (in these experiments an ordinary enameled cake pan was used), and the whole material was placed in an oven which ran at a temperature of 50 to 60° C. When the feces were partially dried other defecations were added to them, and each time they were placed in the oven after fresh feces were added. Upon the addition of fresh feces each time, 5 c. c. of 5 per cent hydrochloric acid was added. After all the feces for the experiment had been collected and the material was dry enough to be used, the pan and feces were taken out of the oven and allowed to come to air dryness, then weighed. This partially dried material was later analyzed.

Nitrogen.—The nitrogen in the feces was determined by the Kjeldahl method, as ordinarily carried out.

Fat.—At first the ordinary method for determining fat in food materials was used, but in connection with other experiments it was found that there was a marked difference between the fat extracted by ether with the ordinary method and that extracted by ether after the feces had been treated with hydrochloric acid and alcohol. Accordingly, in all the samples of feces in connection with these experiments the fat was determined by taking 2 grams of the material and placing it in a small porcelain evaporating dish. To the feces in the dish were added 10 c. c. of water and 2 c. c. of strong caustic soda. The mixture was then heated over a low flame for 10 to 20 minutes,

and the material stirred constantly at first. Enough strong hydrochloric acid was then added to the mixture to more than neutralize the sodium hydroxid which had been previously added. There were also added 10 c. c. of alcohol, and after the mixture was thoroughly stirred over the burner and evaporated on a hot plate until apparently dry it was placed in an oven and dried over night. The dishes were then taken out of the oven and the material allowed to cool. It was then ground with sand and transferred by means of spatula and rubbing with filter paper to special glass-extraction tubes. In this transferring, all of the filter paper used was added to the material in the tube. This was then placed in an ordinary extraction tube connected with a flat flask, and the material extracted with ether for 10 hours. In the extraction of this material by the above process finely divided particles were found in the extract which were not true fatty acids. So it was found necessary after the extraction was completed to filter the material in the fat flask into another weighed fat flask. In filtering, ordinary quantitative filters were used. The ether was then evaporated from that flask, and after drying one to two hours in an oven at 100° C. the material was weighed.

Heat of combustion.—The heat of combustion was determined in the usual manner by means of the Atwater-Hempel calorimetric bomb, described elsewhere.¹

CALORIMETER EXPERIMENTS.

In addition to the ordinary digestion experiments some experiments were made with the subject in the human calorimeter. For this, green cheese and thoroughly ripened cheese were used with the subject sometimes at rest and sometimes doing hard manual labor. The results showed that cheese, both green and cured, was in all respects a good food product, and the results checked up with the other digestion experiments.

SUMMARY OF RESULTS.

The results of the several digestion experiments in the different series are summarized in the following tables. In these tables the results are given for the digestion coefficient of the fat and the availability of the energy, both in the total diet and in the cheese alone.

The amount and exact composition of the basal ration used in the experiments is not given, for the reason that it varied in different experiments with the several subjects, and space will not allow its insertion. All of the data for the entire series of experiments are in the Office of Experiment Stations, Department of Agriculture, Washington, D. C., where they may be consulted by those who wish

¹Atwater and Snell. Journal of the American Chemical Society, Easton, Pa., 1903.

a more detailed account of the work. As previously mentioned, the basal ration was bananas and bread. The amount of cheese eaten per man per day varied somewhat, according to the appetite and preference of the subjects, but an average was not far from 0.5 to 1 pound per day. The exact amount eaten was in every case recorded, as were all other experimental data. While it is believed that the variations in the amount of the basal ration doubtless affected to some extent the digestibility of the cheese, it is thought best not to enter into this subject in this brief account of the work. From the character of the diet it will be seen that practically all of the fat and the greater part of the proteid came from the cheese.

TABLE 1.—*Results of digestion experiments with cheese cured in different ways added to a basal ration. Middletown experiments.*

Kind of rations.	Age of cheese.	Digestibility of proteids.		Digestibility of fat.		Availability of energy.	
		In total diet.	In cheese alone.	In total diet.	In cheese alone.	In total diet.	In cheese alone.
	<i>Days.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>
Low-rennet cheese held at 60° F. added to basal ration of bread and bananas.....	1	88.1	99.4	92.8	95.8	90.9	91.6
	9	86.3	94.3	92.8	95.4	90.0	88.9
	16	88.6	98.3	94.9	97.4	90.8	91.3
	30	86.8	95.2	92.4	94.3	89.6	87.7
	44	88.6	97.0	95.2	97.3	91.2	92.1
	58	88.1	96.9	95.3	97.2	91.0	91.8
	93	91.0	100.6	96.2	97.9	91.8	93.0
	128	87.6	96.1	93.9	96.5	89.5	88.4
	156	90.7	100.3	94.8	96.4	90.7	91.4
	1	89.1	99.7	92.8	95.3	90.8	91.4
High-rennet cheese held at 60° F. added to basal ration of bread and bananas.....	9	88.7	98.7	95.4	97.9	90.5	90.4
	16	88.6	98.3	93.9	95.3	91.1	92.0
	30	85.5	92.6	93.1	97.1	89.2	86.5
	44	88.4	97.8	95.0	96.4	90.7	91.1
	58	87.4	94.7	93.9	97.0	90.3	89.8
	86	89.0	97.2	94.3	95.9	90.8	91.4
	115	90.0	100.5	92.6	95.0	90.0	89.6
	142	91.1	100.4	94.5	96.1	91.1	92.5
	30	87.0	95.7	93.8	95.8	90.5	90.2
	44	88.1	96.2	94.4	95.4	90.8	90.9
Low-rennet cheese held at 40° F. added to basal ration of bread and bananas.....	58	90.5	101.5	93.7	95.4	91.3	92.8
	30	87.8	97.0	92.5	94.5	90.3	89.7
	44	85.4	91.6	94.6	96.6	90.4	89.6
	58	89.4	99.6	95.3	97.1	91.4	93.2
	128	89.9	101.1	94.9	97.5	90.7	91.5
	155	88.9	98.0	94.3	95.9	90.4	90.7
	9	86.6	94.9	94.3	96.8	90.3	89.7
	16	87.1	95.4	91.7	93.1	90.1	89.3
	30	86.9	95.2	93.6	97.6	90.3	89.6
	44	88.0	97.2	94.0	95.3	90.8	91.3
High-rennet cheese placed at 40° F. when two weeks old added to basal ration of bread and bananas.....	58	90.8	100.7	94.6	97.7	91.2	92.3
	30	89.4	99.7	94.7	98.8	91.3	92.6
	44	90.4	101.8	95.2	96.6	91.5	93.5
	58	90.3	99.9	95.7	99.0	91.3	92.4
	115	89.9	101.2	94.5	97.2	90.5	91.0
	142	92.6	104.5	94.8	96.4	91.5	93.4
	9	90.3	102.1	94.7	97.4	91.2	92.5
	30	86.0	93.9	94.2	96.2	89.9	88.4
	44	84.6	90.3	92.0	93.9	89.7	87.6
	58	88.1	97.3	94.8	96.6	91.2	92.4
Low-rennet cheese held at 32° F. added to basal ration of bread and bananas.....	9	84.9	91.7	91.5	93.8	89.6	87.9
	16	89.7	100.4	92.7	94.1	90.9	91.6
	30	87.4	96.1	94.4	98.5	90.5	90.5
	44	89.5	100.1	94.5	95.9	91.2	92.7
	58	89.2	98.0	92.8	95.9	90.7	91.0
	9	84.9	91.7	91.5	93.8	89.6	87.9
	16	89.7	100.4	92.7	94.1	90.9	91.6
	30	87.4	96.1	94.4	98.5	90.5	90.5
	44	89.5	100.1	94.5	95.9	91.2	92.7
	58	89.2	98.0	92.8	95.9	90.7	91.0
Low-rennet cheese, green curd, added to basal ration of bread and bananas.....		89.2	99.1	93.4	96.9	89.7	88.8

¹ This figure, as well as a number of others, shows that the digestibility of protein in the basal ration was evidently higher in these particular experiments than was assumed.

The results in the table show that there is little or no difference in the comparative digestibility of cheese at different stages of ripening. The perfectly green curd was evidently as digestible and, so far as nutritive value was concerned, was as good a food as the same cheese at any stage of ripening. The casein of cheese either fresh from the press or thoroughly ripened is very highly digestible. The cheese was eaten in comparatively large quantities, but it was evidently well assimilated.

A record of the health of each individual was kept, and also notes on the palatability of the cheese ration. At first 1,350 grams of bread were fed with 2,025 grams of bananas and 450 grams of cheese. The length of the experiment was three days, and this would make practically one-third of a pound of cheese per day. The bread was finally reduced to 1,200 grams and the cheese increased first to 525 grams and then to 600 grams for the three days. On the whole, the cheese was very palatable and, with a few exceptions, the amount given was not considered excessive by the person eating it. A number of the subjects wanted more of the cheese. The subjects of the experiments were about equally divided in the preference for a mild or a strong cheese.

Contrary to general belief, the green curd did not appear to cause constipation. In fact, constipation resulted more frequently after the cheese had had time to become well ripened. There also seemed to be more distress from the cheese diet with the well-ripened cheese than with the green cheese. On the whole, however, the cheese made a very satisfactory food. Fully as many instances were recorded of minor bowel disturbances corrected during the experimental period as of those which occurred during the same time.

EXPERIMENTS AT MINNESOTA AGRICULTURAL EXPERIMENT STATION.

As has been previously noted, during the year following the work at Middletown further experiments were made in cooperation between the Office of Experiment Stations and the Minnesota Agricultural Experiment Station. The primary object of these experiments was to study the digestibility of older cheese than had been previously used. In addition, the digestibility of other varieties of cheese was studied, as well as the so-called condimental value of some of the more highly flavored varieties.

GENERAL OUTLINE OF THE WORK.

The experiments included the following series of rations:

1. Old well-cured cheese in medium amounts, with bread and oranges.
2. Old well-cured cheese in large amounts, with bread and oranges.

3. Roquefort cheese in large amounts, with bread and oranges.
4. Green cheese in medium amounts, with bread and oranges.
5. Green cheese in large amounts, with bread and oranges.
6. Swiss cheese in medium amounts, with bread and oranges.
7. Skim-milk cheese in large amounts, with bread and oranges.
8. Camembert cheese in large amounts, with bread and oranges.
9. Camembert cheese in small amounts, with bread and oranges.
10. Roquefort cheese in small amounts, with bread and oranges.
11. Cottage cheese, with bread and oranges.

In order to determine the digestibility of the basal ration of bread and oranges used alike in all the trials with cheese, a number of digestion experiments were made with bread and oranges alone, bread and oranges with milk, and bread and oranges and butter.¹ It is to be noted that in these digestion trials and the trials with cottage cheese an opportunity was offered for determining the influence which the milk fat and the casein had alone and in combination upon the digestibility of the ration.

In all the experiments the conditions were alike, and the result of one experiment is strictly comparable with the results of the others. The subjects employed were university students, who were engaged a part of the time at light manual labor. Four subjects were used in each experiment and the same four subjects were used in each series.

In all the digestion trials the experimental period was three days. A preliminary meal preceded the experiment proper and at the close an additional meal was eaten; this enabled the feces for the experimental period to be carefully separated.

The methods of the Association of Official Agricultural Chemists were used for the analyses of the food materials and feces. The fat of the feces was also determined by a modified method that had been used in the experiments at Middletown. In the calculation of the digestion coefficients the results of the modified method were used except in a few cases where the results were evidently too high, and where the calculated calories using the association's results checked more closely with the determined calories than when the modified fat results were used.

DESCRIPTION OF SAMPLES.

Most of the bread was made in a small home bakery and the remainder at the experiment station laboratory in connection with other experiments. The old cheese was from the same lot, made for the Middletown experiments, and was about 18 months of age, having

¹ The details of these experiments are not given in this paper, but it is planned to publish them in a fuller report of this work by the Office of Experiment Stations of this department, and anyone desiring to make a more detailed study of the experiments can consult this larger publication when it appears.

been kept in cold storage for the entire period. It was thoroughly broken down, high flavored, and was pronounced to be of excellent quality.

The skim-milk cheese was evidently not a so-called full skim, but from the composition must have been what is usually termed a two-thirds skim, as the cheese contained 11 per cent of fat. It was purchased on the Chicago market. The green cheese was furnished by a factory in Minnesota. The other cheeses were bought from wholesale dealers in St. Paul, Minn.

SUMMARY OF RESULTS.

The results of the Minnesota experiments are shown in the following table:

TABLE 2.—*Results of digestion experiments with cheese of different kinds added to a basal ration. Minnesota experiments.*

[In each case the value represents the average of experiments with four subjects.]

Kind of ration.	Digestibility of nitrogen—		Digestibility of fat in total diet. ¹	Availability of energy—	
	In total diet.	In cheese.		In total diet.	In cheese.
Old cold-storage cheese (435 grams added to basal ration).....	<i>Per cent.</i> 92.53	<i>Per cent.</i> 91.79	<i>Per cent.</i> 91.04	<i>Per cent.</i> 92.33	<i>Per cent.</i> 86.13
Old cold-storage cheese (585 grams added to basal ration).....	93.79	96.36	93.64	92.21	87.08
Green cheese (750 grams added to basal ration).....	94.39	96.29	89.96	92.29	86.45
Green cheese (1,050 grams added to basal ration).....	94.33	95.83	93.72	91.25	86.40
Roquefort cheese (520 grams added to basal ration)...	93.13	93.57	91.04	92.40	87.15
Swiss cheese (605 grams added to basal ration).....	92.67	92.19	90.84	92.00	84.38
Skim-milk cheese (1,000 grams added to basal ration)...	95.10	96.65	88.55	90.47	79.68
Camembert cheese (605 grams added to basal ration)...	91.65	88.65	89.17	92.87	83.59
Camembert cheese (240 grams added to basal ration)...	91.07	83.22	80.86	92.25	74.95
Roquefort cheese (295 grams added to basal ration)...	90.82	82.59	88.70	92.41	82.18
Cottage cheese (540 grams added to basal ration).....	92.85	92.68	90.98

¹ Because of the fact that the basal ration of bread and oranges is practically free from fat, the digestibility of the fat in the total diet and in the cheese alone may be considered to be identical.

In the discussion of the results and the interpretation of the digestion coefficients it is believed that the calories should be taken as the indirect index of digestibility of the fats rather than the fat determinations.

In the calculation of the results it was assumed that the bread and oranges had the following digestibility: Protein, 93 per cent; carbohydrates, 98 per cent; calories, 98 per cent.

As so little fat was contributed by the bread and oranges, it was deemed best by Prof. Snyder, under whose direction the tables of results were prepared, not to make any special calculations for the digestibility of the fat of the cheese alone.

The factor for the digestibility of the protein of the bread and oranges is higher than was found in the numerous experiments for

bread alone, but it was assumed because it appeared from the first series of results that cheese in the ration increased the digestibility of the protein of the other foods. This assumption appeared to be verified by the later tests which had for their special object the influence of the cheese upon the digestibility of the basal ration.

The work both at Middletown and in Minnesota, while demonstrating the same general fact of the high food value, actual and comparative, of cheese in all stages of ripening, does not give identical figures for the digestibility of protein in the total diet or in the cheese. A different basal ration was used in the Minnesota experiment from that used at Middletown. White bread was used in Minnesota, while whole-wheat bread, which has a decidedly lower digestibility, was used in the experiments at Middletown.

Nothing unusual was noted in the health of the subjects used in the experiments at the Minnesota Experiment Station. One of the subjects believed before beginning the experiments that a cheese diet did not agree with him, but found that it had no ill effects.

In considering the results shown in Table 2 it is apparent that all the kinds of cheese used in the experiments are very digestible. In comparing the old cheese with the green cheese the latter was evidently the more digestible, which was not the case in the Middletown experiments, where the slight difference was in favor of the well-cured cheese. However, the difference between the digestibility of green and cured cheese in either series of experiments is well within the limits of variation ascribable to personal peculiarity of the subjects and were to be expected in this kind of work.

Particular interest attaches to the evident digestibility and food value of the skim-milk cheese. This is a product which has not been viewed with very great favor by the public in general. The physical properties of cheese made from skimmed milk have been such as to give consumers the impression that it was indigestible and, on the whole, of questionable value as food. The establishing of the actual food value of this comparatively cheap product will at some future time doubtless be of great economical importance. Skim-milk cheese made up in a way to be agreeable to the taste could be sold at a price that should attract the attention of the laboring classes. Cheese made from skimmed milk and sold for whole-milk cheese is a fraud that is a positive injury to the dairy business; but cheese made from skimmed milk and sold for what it is worthy of serious consideration on the part of both producer and consumer. It is very likely that the time is not many years distant when a comparatively large quantity of cheese from skimmed milk will be made with profit to the dairy industry and will be consumed at a pronounced saving by the laboring class in general.

In the same connection attention is called to the food value of cottage cheese established by this work. This is another cheap and to many a very palatable product that could be introduced to a much greater extent in the dietary at a great saving in the total cost of food.

In general, the table shows that all kinds of cheese, even the very high-flavored and so-called condimental cheeses, have a high food value. But the so-called condimental value of cheese when eaten in small quantities as a stimulus to the digestion of other foods was not demonstrated. Where the cheese was eaten in small quantities the digestibility of the basal ration fell below the assumed digestion coefficient. The fact that in the work done at Middletown the digestibility of the basal ration was increased in many cases at least is no evidence that cheese has any particular properties as a stimulant to digestion as it has been shown that other foods, such as meat, might have the same effect. This is a physiological phenomenon that may perhaps be explained on some other basis than that of condimental effects.

CHEESE AS AN ARTICLE OF DIET.

While the experiments herein described have established the facts as to some debatable questions concerning the comparative digestibility of green and cured cheese, perhaps the most valuable result has been in showing clearly the great value as food of all the more common varieties of cheese.

The Swiss, who are a very healthy people, eat largely of cheese; in fact, bread and cheese form the greater part of the diet of many of them. Many other European races eat largely of cheese. The miners of England consume very much of the poor cheese made in the United States, especially the high-acid cheese, using it extensively for seasoning; and the Germans eat large quantities of the cheap but highly flavored skim-milk cheese such as the hand käse, which has perhaps the most pungent odor of all the varieties of cheese made.

In the matter of comparative food values it was thought that the results of the experiments given in this report made it safe to assume that cheese was as fully digested as most of the ordinary food materials which have been studied in earlier experiments carried on in connection with the nutrition work of the Department. It would in fact be undesirable for a larger per cent of any food material to be absorbed than was the case with the cheese.

Heretofore cheese has seldom been regarded seriously by consumers of any class in the United States as a possible cheap staple food. All consumers of cheese with very few exceptions use it as a luxury in small quantities at comparatively rare intervals. While in the aggre-

gate a large quantity of cheese is eaten in the United States, the quantity is nevertheless almost negligible when compared with some other products of less food value and inferior palatability.

The greater part of the cheese consumed in this country is eaten without any preparation, while in many European countries the cheese is either sprinkled on other foods—vegetables usually—or is cooked with the food. Americans evidently have much to learn from Europeans of some of the possibilities of preparing such dishes. A number of European varieties of cheese are made extensively and exclusively for use in connection with other foods or in cooking. Among these is the well-known Parmesan, a hard cheese made from skimmed milk; and also the sap sago cheese, a small conical-shaped cheese made from skimmed milk and highly seasoned with herbs. The Italians use cheese for flavoring as Americans use salt and pepper, having it grated and constantly at hand in a small shaker. With them macaroni with cheese is a common dish, as are other cheese preparations. An excellent dish is the cheese omelet, while warmed-up potatoes can be made very appetizing when cooked with cheese.

It may be, perhaps, that the American people have gone so far in the consumption of only partly ripened and mild-flavored cheese that the probabilities of learning to use cheese as a flavoring are very remote, as it is only the well-ripened or highly flavored cheeses that are satisfactory for flavoring purposes. It is perhaps a matter for some regret that so much mild-flavored cheese has come to be used, as it is probable that much more satisfaction would be felt by consumers in general with this great food product if they had learned to like the well-ripened product with a well-developed flavor. It is generally conceded that people who like a highly-flavored cheese never become tired of it.

A comparison of the food value of cheese with that of other highly nitrogenous food materials may be of interesting value. No kind of meat excepting dried beef carries such a large percentage of protein as cheese, and as dried beef contains a much greater percentage of water, the other food constituents aside from the protein are much less than is found in cheese. Fresh beef as purchased has, weight for weight, little more than half the food value of cheese in either protein or fat, and the same is true of practically all other fresh meats, which have in many cases such a large percentage of refuse and in all cases such a large percentage of water that they are noticeably inferior to cheese in food value. Bacon or fat pork are exceptions, but their food value is mostly in the fat, which can be and is replaced to a great extent by the carbohydrates of vegetables at a much less cost and sometimes perhaps at a benefit to the health of the consumer.

Fish and pork each have a notably large percentage of refuse, while eggs have a high percentage of water. To sum the matter up, a pound of cheese has nearly the same food value as 2 pounds of fresh beef or any other fresh meat as food; it is worth as much as or more than a pound of ham and is more digestible, and it is equal to 2 pounds of eggs or 3 pounds of fish. In price good cheese made from unskimmed milk costs about a third more than round steak and twice as much as the cheaper boiling beef, while it costs practically the same per pound as smoked ham and bacon. It costs usually a third more than fresh fish.

Cottage cheese or cheese made from partially skimmed milk is cheaper even than the American of Cheddar cheese. The first costs about one-third as much and the partly skimmed product, about two-thirds as much as the so-called "full cream" cheese. Practically the only food product that rivals cheese in food value and cheapness is dried beans.

In view of the foregoing comparison of food values it is a matter of some wonder why there is not more of a demand for cheese, especially by people of limited means. Estimates made by the Department of Agriculture, in the Twenty-second and Twenty-sixth Annual Reports of this Bureau and in Bulletin 55 of the Bureau of Statistics, show that the people of the United States consume between 169 and 185 pounds of meat annually per capita, besides fish and poultry, while the annual consumption of cheese is only about 4 pounds per capita. Even granted that fresh meats are more palatable to most people, some other explanation must be found for this wide difference in the quantity of the two products eaten. A great proportion of the laboring class in this country are able to eat plenty of wholesome food, but they can not afford to discriminate against a cheap, palatable, and wholesome food in favor of a higher-priced food. The only way to account for the comparatively limited demand for cheese is on the basis of custom and lack of knowledge. People usually eat what they have been accustomed to, making variations within narrow limits only, and never changing the general character of their food. New foods are not sought.

In this connection particular interest attaches to the quantity of salt or cured pork products eaten in comparison with cheese. Cured pork, ham, and bacon, to about seven times the value of cheese are eaten annually. No one can say that the pork products, with the exception of good ham, are more palatable than cheese, and they are not known to be more healthful. These pork products are usually eaten by the poorer classes who can not afford to buy fresh meat but who could afford to buy cheese, and cheese makes a better food in the dietary, because of its high protein content.

Cheese can no longer be discriminated against because of a suspicion that it is not a healthful food. The absolute lack of any disturbance of the general health of the subjects used in the experiments reported in this bulletin is proof that cheese can be eaten in large quantities without danger to health. The Swiss cheesemakers, also many of the Swiss farmers of southern Wisconsin, eat unusually large quantities of cheese, and they are noted for athletic attainments and physical endurance. They brought the custom of eating cheese from their native country, where cheese is a very important item in the diet. The consuming public, especially that part of it which needs to practice economy in buying food, would do well to turn its attention a little more toward cheese, since greater quantities can be used at a saving to the consumer.

